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Prevalence of Mosquito Species and Malaria Transmission in three riverine communities in Bali district, Taraba state, Nigeria

Lamidi, B.T., Elijah, M. I. and Ireebanije, F.J.
Department of Science Laboratory Technology, Federal Polytechnic, PMB 05 Bali, Taraba state, Nigeria
Corresponding Author: Lamidi, B.T

Abstract: *Effective transmission of mosquito-borne disease requires successful contact between female mosquitoes and their hosts. Investigations on the prevalence of mosquito species and infective biting rate of Anopheles were made between June and December, 2018 in Bali district, Taraba state, Nigeria. Collection of mosquitoes by use of non-residual insecticide-pyrethrum (Spread Sheet Collection) was employed using World Health Organization (WHO) standard in three riverine communities of Daniya Bali, Fundalara and Gazabubarkeji Human Blood Index (HBI) and Plasmodium sporozoite infection of the fed Anopheles gambiae was determined using biochemical method (ELISA). A total of 614 mosquitoes were morphologically identified comprising of four species: Anopheles gambiae complex 589 (96.0%), Mansonia uniformis 11 (1.8%), Culex quinquefasciatus 12 (1.9%) and Aedes aegypti 2 (0.3%). Fundalara village had the highest mosquito population of 325 (52.9%), followed by Gazabubarkeji 194 (31.6%). The least was in Daniya Bali 95 (15.5%). ANOVA showed significant difference between mosquito abundance and study areas (P < 0.05). Prevalence of mosquito catch in seasons showed that there were more 509 (82.9%) than in dry season 105 (17.1%) Based on sex, female mosquitoes were more abundant 510 than the male 104 caught indoor. Among the 485 Anopheles gambiae, 191 were fed with HBI of 1 (100%) and Man-Biting Rate (MBR) 1.93 bite/man/night, sporozoite rate (SR) of 0.005 and Infective Biting Rate of 0.01. The SR and IBR were only recorded in wet season. Also the MBR during wet season 1.86 bite/man/night was more than that of dry season 0.07bite/man/night. T- test showed significant difference in mosquito abundance in seasons (P<0.05) but no statistical difference between MBR, SR and IBR in seasons (P>0.05) The implication of these findings is that the study area is prone to various mosquito-borne diseases especially malaria with possible higher transmission in wet season of the year.*

Keywords*: mosquito, Anopheles, prevalence, malaria, Bali*

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I. Introduction

Mosquitoes (Class Insecta; family Culicidae) are still considered as the most dangerous animal because their females feeds on human blood and thus transmit extremely harmful diseases, such as malaria, yellow fever and filariasis (1, 2). They are estimated to transmit diseases to more than 700 million people annually and responsible for the death of about 1 in 17 people (3). Effective transmission of mosquito-borne disease requires successful contact between female mosquitoes and their hosts (4). Among the culicids, the members of the genus *Anopheles, Culex, Mansonia and Aedes* are best known for their role in transmitting diseases worldwide (2, 5). Of these diseases, malaria caused by *Plasmodium* parasite is one of the greatest killer diseases in the world (5). WHO (2013) reported an estimated 207 million cases of malaria in 2012 out of which 200 million cases (80.0 %) were in Africa continent. The distribution pattern, transmission and intensity of the disease are dependent on the degree of urbanization and the distance from vector breeding sites (6). The endemicity of malaria in any region is determined by indigenous *Anopheles* mosquitoes, abundance, feeding, resting behavior and their *Plasmodium* infectivity, among other factors (7, 8, 9, and 10).

The targets of the Global Technical Strategy for Malaria 2016–2030 (GTS) are by 2030: to reduce malaria incidence and mortality rates globally by at least 90% compared with 2015 levels; to eliminate malaria from at least 35 countries in which malaria was transmitted in 2015; and to prevent re-establishment of malaria in all countries that are malaria free (8)

The high transmission rate and prevalence of malaria is a result of the diverse mosquitoes breeding sites, which include practically receptacle that holds water, such as tins, cans, old tyres, tree holes, cisterns, open pools, drainage, stream and pond (11). Part of the efforts being made is the official commemoration of April 25 every year, starting from 2008 as World Malaria Day and August 27 as World Mosquito Day (WMD) (12).

People living in poor rural areas are confronted with a multitude of barriers when assessing malaria prevention especially on the knowledge of the biology and ecology of the vectors, among others (11, 13, 14).

The species composition and other biological parameters of the mosquitoes are poorly known in different parts of Nigeria, the knowledge of which is required in the design of vector control programmes and in tackling the prevalence of the disease in endemic areas (15). Taraba State of Nigeria is endemic to malaria with reported prevalence of 80.0% in some areas of the state and diversity of mosquito species especially in Bali town (16, 17).

The study investigated the population structure of prevalent mosquito species including infectivity of *Anopheles* species in relation to malaria infection in three riverine communities in Bali district of Taraba state Nigeria. The study will contribute more to the epidemiology of mosquito-borne disease in the communities.

II. Materials and Methods

2.1 Study Area: Taraba State is located between longitude $8.5^{o} – 11.6^{o}$E and latitude $6.5^{o} – 9.5^{o}$N (8^{o} 00'N and 10^{o} 3O'E coordinates) in the north-eastern geopolitical zone of Nigeria with a size of 54,473 square kilometers representing 5.89% of the country landmass (Wikipedia, 2015). It has an estimated population of 2,688,944 based on 2006 census, giving a population density of 27 people per km^2, representing 1.90 % of the total population of Nigerians (Wikipedia, 2015).The study was carried out in three major riverine communities of Bali district of Taraba State (central zone, 7^{o} 22'- 8^{o} 48'N; 10^{o} 17' – 11^{o} 49'E): Fundalara, Gazabubarkeji and Daniya Bali.

The study communities were selected based on dense population, house types, presence of water bodies, both permanent slow running ones and stagnant prevailing pools of water that serve as breeding places for mosquitoes.

Bali, Taraba State is in guinea savanna (semi-arid) zone of the country. Rainy season is between May and early October and dry season between November and April. Daily temperature varies from 37^{o} to 40^{o}C during the hottest months of March/April. It also varies from 32^{o} to 37^{o}C during the coldest months of December/January. The relative humidity is about 23.00 % during the hot dry weather and can reach 80.00 % during the peak of wet season in July/August (18).

2.2 Mosquito Sampling: Indoor mosquito collections were carried out every month of the study period (June to December, 2018), in each of the sites covering wet and dry seasons. Ten bedrooms were selected randomly from each station with at most three bedrooms from the same house. 180 (6 months x 10 bedrooms x 3 sites) rooms were sprayed during the entire period of study.

Collection of mosquitoes by use of non-residual insecticide-pyrethrum (Spread Sheet Collection) was employed using World Health Organization (WHO) standard procedure (19, 20) and complemented with electronic mosquito hitting racket. All knocked down mosquitoes were preserved fresh in ice pack and taken to laboratory.

2.3 Laboratory Examination of Mosquitoes: Collected and preserved mosquitoes were sorted, morphologically identified to species level (21, 22) before further processing.

2.3.1 Morphological Identification and Sorting out of Mosquitoes: Anopheline were separated from Culicine mosquitoes according to the morphological characteristics of their maxillary palps the patterns of spots on the wings, thorax and terminal abdominal segments, scales of the legs using dissecting microscope following the taxonomic keys (1, 21 - 26).

The thorax/head and abdominal regions of identified Anopheles were collected into properly labeled Eppendorf tubes and preserved over silica gel (7, 20)

2.3.2 Recognizing blood digestion states: Based on their blood digestion stage or abdominal condition, anophelines were grouped as unfed, freshly fed, half-gravid, and gravid as described by WHO (7)

2.3.3 Estimation of Infective (Sporozoite) Rate of *Anopheles*: Enzyme-Linked Immuno-sorbent Assay (CSP-ELISA) was used for the *Anopheles* mosquitoes. The head and thorax of *Anopheles* caught was separated from the abdomen and tested for the presence of *Plasmodium* species sporozoite following the standard method (7, 27)

Sporozoite (infective) rate of *Anopheles*

$$\text{Sporozoite Rate, (SR)} = \frac{\text{infected mosquito species}}{\text{Total particular species examined.}}$$

2.3.4 Source of Blood meal/Host preference ELISA

The blood meal sources of blood fed samples collected was determined as described by WHO (27).

Human Blood Index, HBI = Number of *Anopheles* mosquito with Human blood
Total number of the mosquito species with blood

2.3.5 Determination of Man -Biting Rate:
Bites per person per day, month, season or year determined according to WHO (7)
I.e Human Biting Rate =Freshly fed *AnophelesX* Proportion Fed on humans (HBI)
Number of occupants who spent the night in the rooms used for collection

2.3.6 Determination of Infective Biting Rate/Transmission Potential/Entomological Innoculation Rate (EIR)
This is the product of Human Biting Rate and Proportion of Infective mosquito standardised to the average number of days in a month (30.5) or a year 365 to arrive at the infective biting rate (7).

2.3.7 Data Analysis
Relative frequencies (percentage) were used for the presentation of data in tables. Analysis of Variance (ANOVA) was used to analyze the followings: mosquito abundance and selected communities; Student t test was however used to analyse variations in mosquito catches and Infective Biting Rates of female Anopheles in wet and dry seasons to determine significant variation using SPSS.

2.3.8 Ethical consideration: Before the commencement of the study, Bali Local Government/Health Authority was contacted for consent and onward delivery to the District head and community leaders/village heads. Verbal consent was obtained from heads of the households. As compensation for their cooperation, each house hold was given a pyrethroid insecticide for further use and advised appropriately on mosquito control methods.

III. Results

Table 1: Abundance of mosquito species in the study communities

Mosquito species	Study communities within Bali district			Total (%)
	Daniya Bali No (%)	Fundalara No (%)	Gazabubarkeji No (%)	
Anopheles gambiae	85 (87.5)	316 (97.2)	188 (96.9)	589 (95.9)
Mansonia uniformis	7(7.4)	3 (0.9)	1 (0.5)	11 (1.8)
Culex quinquefasciatus	2 (2.1)	6 (1..8)	4 (2.1)	12 (1.9)
Aedes aegypti	1 (1.1)	0 (0.0)	1 (0.5)	2 (0.3)
Total (%)	95(15.5)	325 (52.9)	194 (31.6)	614

Table 1 shows the relative abundance of mosquito species in the study communities. Among 614 mosquitoes collected in the study period (June to December, 2018), *Anopheles gambiae* were predominant with 589 (95.9%) followed by *Culex quinquefasciatus* 12 (1.9%), *Mansonia uniformis* 11 (1.8%). The lowest was *Aedes aegypti* 2 (0.3%).

Fundalara village recorded the highest number of mosquitoes 325 (52.9%), followed by Gazabubarkeji village 194 (31.6%) and the least was in Daniya Bali with 95 (15.5%). Among the mosquito species, *Anopheles gambiae* was dominant in all the communities with 97.2%, 96.9% and 87.5% in Fundalara , Gazabubarkeji and Daniya Bali respectively. *Mansonia uniformis* was collected most in Daniya Bali, the least was in Gazabubarkeji. *Culex quiquefasciatus* was collected most in Fundalara and the least was in Daniya Bali. No *Aedes* mosquito was collected in Fundalara

Table 2: Seasonal abundance of mosquito species identified based on sex

Seasons Of the Year, 2018	Number (percentage) catch for mosquito species identified								Total (%)
	An. gambiae		*Man. uniformis*		*Cx. quinquefasciatus*		*Ae. aegypti*		
	Female	Male	Female	Male	Female	Male	Female	Male	
Wet	413 (84.4)	78 (15.6)	7 (100)	0	10 (71.4)	4 (28.6)	1 (100)	0	509 (82.9)
Dry	72 (73.5)	27 (26.5)	4 (100)	0	2 (100)	0	1 (100)	0	105 (17.1)
Total (%)	485 (75.0)	104 (25.0)	11 (100)	0	12	4	2	0	614 (100)
							(82.3)	(17.7)	

Table 2 shows that among the mosquito species collected in both wet and dry seasons. The female mosquitoes predominated in the catches made, although wet season catch was more abundant than the dry

season in all the species. Generally, in wet season mosquitoes were predominant 509 (82.9%) than the dry season 105 (17.1%)

Table 3: Man-Biting Rate and Infective Biting Rate of *Anopheles gambiae*

Seasons	No (N)	f/fed (FF)	Man Night (MN)	MBR (FFxHBI/MN	Sporozoite rate (SR)	IBR (MBR x SR)
Wet	413	186	100	1.86	0.005	0.01
Dry	72	5	88	0.07	0	0
Total	485	191	188	1.93	0.005	0.01

Man-Biting Rate (MBR), Sporozoite Rate (SR) and Infective-Biting Rate (IBR) of *Anopheles gambiae* showed that the *Anopheles* species bite more in wet season (1.86) than in dry season (0.07). The sporozoite (infective) rate of the Anopheles was 0.005 and only in wet season. Therefore the Infective Biting Rate (IBR) was only recorded in wet season (0.01) (Table 3).

IV. Discussion

This study is an extension of the study conducted in a riverine community of Bali town among other areas where Bali recorded highest mosquito diversity (14). *Anopheles gambiae sensu lato* had been recorded to be predominant mosquito species in Bali town as found in this study which as extended to other riverine communities of the Bali district (14, 16). The prevalence of *Anopheles* in this study is also in line with the work of other researchers in other states of Nigeria especially Katsina and Kwara states which is 93.3% (13, 28)

Notwithstanding that the species of mosquito genera collected were not diverse; the identified species were those that were dominant species in the previous research in Taraba state, Bali town inclusive. The predominance of *Culex quiquefasciatus* among the *Culex* species, *Mansonia uniformis* and *Aedes aegypti* that only featured among other *Mansonia* and *Aedes* genera in other research authenticate the findings of this study within the limited study period (14)

All the mosquito species collected in this study are proven vector of some human diseases. *Culex* and *Mansonia* species are vectors of bancroftian filariasis (29). *Aedes aegypti* which lives in tropical climates is a vector of yellow fever and zika virus (29). *Anopheles gambiae* identified in this study is a vector of malaria and filariasis (29)

Seasonal variation of abundance of mosquito species which showed that mosquitoes were more abundant in wet season than in dry season is in line with the findings of other researchers (9, 16). This might be due to the favourable ecological conditions for breeding of mosquitoes in wet seasons unlike the case of dry season (9). The dry season mosquitoes was very low in this study not just because of lack of rain and availability of various stagnant waters, but because it was a cold/harmattan period that the collection was made. Low temperature increases the duration of mosquito metamorphosis (20). The female: male mosquito ratio was very high. This is in contrast with the study conducted in Nguru Yobe state (30). This might be because male mosquitoes are not anthropophilic so they need to stay outdoor in most times to feed on flower nectar and mate with exophilic/exophagic mosquitoes also.

The *Anopheles gambiae* collected were anthropophyhilic as it was found in previous research in this area even with other identified *Anopheles* species (16). The Man-Biting Rate (MBR) was found to be higher during wet season in this study than in dry season. This is in line with the findings in the previous research (31, 32).The *Plasmodium* (sporozoite) infection in *Anopheles gambiae* was found in the wet season only, although it was very low. This might be due to the fact that wet/hot season favours propagation of malaria parasite by lowering the incubation period of the sporogony in the gut of *Anopheles* thereby enhancing infective biting and malaria transmission (20, 32, 33)

V. Conclusion

The occurrence of these species of mosquitoes in the study areas shows that the communities are at risk of contacting mosquito-borne diseases since all of them are proven vectors of dreadful diseases. The intervention efforts should be geared up mostly in the wet/hot season which is of epidemiological significance especially to malaria disease

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